AP PHYSICS C: MECHANICS • EXERCISE SHEET

2.6 Gravitational Force

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS weight 重量 • force 力

Objective

Build the skills to answer exam questions on **gravitational force**.

You must be able to:

- find **weight** 重量 near Earth's surface: $W = mg$
- use **Newton's law of universal gravitation** 万有引力定律: $F = \dfrac{GMm}{r^2}$
- explain that gravity is an inverse-square force
- distinguish mass (constant) from weight (depends on g)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ **Weight near a surface**

$$W = mg.$$

A 5 kg mass on Earth ($g = 9.8$ m s^{-2}) weighs $W = 5 \times 9.8 = 49$ N.

■ **Universal gravitation**

Between any two masses,

$$F = \frac{GMm}{r^2},$$

where r is the centre-to-centre distance. Doubling r quarters the force (inverse square).

■ **Mass versus weight**

Mass is the same everywhere; weight changes with g. On the Moon ($g \approx 1.6$ m s^{-2}) the 5 kg mass weighs only 8 N, but its mass is still 5 kg.

2 Practice

Now apply the methods above.

2.1 Find the weight of a 12 kg object on Earth ($g = 9.8$ m s^{-2}). [2]

2.2 In $F = GMm/r^2$, what happens to the force if r doubles? [1]

2.3 State one quantity that stays the same and one that changes when you travel from Earth to the Moon. [2]

2.4 A 2 kg mass weighs 3.2 N on the Moon. Find the Moon's g. [2]

3 Exam-style questions

3.1 The gravitational force between two masses is proportional to [1]

- **A** r
- **B** $1/r$
- **C** $1/r^2$
- **D** r^2

3.2 An astronaut's mass on the Moon compared with on Earth is [1]

- **A** smaller
- **B** larger
- **C** the same
- **D** zero

3.3 Two satellites orbit a planet. Satellite B is twice as far from the centre as satellite A.

(a) State how the gravitational force on B compares with that on A (same mass). [1]

(b) Explain using the inverse-square law. [2]

3.4 A rock has a mass of 3 kg.

(a) Find its weight on Earth ($g = 9.8$ m s^{-2}). [1]

(b) State its weight and mass on a planet where $g = 20$ m s^{-2}. [2]

Solutions

2.1 $W = mg = 12 \times 9.8 = 118$ N.

2.2 It falls to one quarter (inverse square).

2.3 Mass stays the same; weight changes (because g changes).

2.4 $g = W/m = 3.2/2 = 1.6$ m s^{-2}.

3.1 **C** — gravity follows an inverse-square law.

3.2 **C** — mass is the same everywhere.

3.3 (a) The force on B is one quarter of that on A. (b) Doubling r makes $1/r^2$ one quarter, so the force is quartered.

3.4 (a) $W = 3 \times 9.8 = 29.4$ N. (b) Mass still 3 kg; weight $= 3 \times 20 = 60$ N.